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FUNGICIDE COMPOSITIONS

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of United States Provisional Application Serial No. 60/347,208 filed on January 9, 2002, which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

The present invention relates to compositions and methods for treating plants and agricultural products.

Fungus can often attack and destroy crops and, if not kill them, can induce distress in the crops so that they succumb to other diseases and/or significantly lower crop yield. Furthermore, agricultural products can be particularly susceptible to damage by fungus after the products are harvested. Many of the products are stored for extended periods of time before they reach the consumer or are used by the consumer. The fungus can make the harvested agricultural products inedible or otherwise unusable. This can be particularly problematic since a significant amount of effort and money has gone into producing and harvesting the agricultural products; all of this can be lost before the products reach the consumer.

Consequently, it is not surprising that there are many fungicide compositions currently on the market. However, there is a growing concern that some of these compositions, one or more of their components, and/or metabolites eventually find their way into the food sources for animals, including humans. Unfortunately, many fungicides and/or their byproducts are moderately and even extremely toxic. Further, some fungicides are suspected or known carcinogens. Despite this fact, many fungicides continue to be used and are needed to protect cash crops. It is important to note that some fungi are themselves extremely toxic or produce toxic components. For example, aflatoxins belong to a class of fungal metabolites and are known to occur naturally in many products including peanuts,

cottonseed, corn, peppers, etc. Many aflatoxins are extremely toxic and some are listed as known carcinogens. Consequently, fungicides are needed to protect and preserve agricultural products and ensure the public's health.

Consequently, with increased demand and necessity for agricultural products to feed and clothe the world population, and with the risks associated with eating and using diseased products, there is an increased need in the field for advancements. These advancements include improved methods and compositions for treating plants, particularly cash crops and products derived from the plants. The present invention is such an advancement and provides a wide variety of benefits and advantages.

SUMMARY OF THE INVENTION

The present invention relates to novel agricultural compositions and use thereof. Various aspects of the invention are novel, non-obvious, and provide various advantages. While the actual nature of the invention covered herein can only be determined with reference to the claims appended hereto, certain forms and features, which are characteristic of the preferred embodiments disclosed herein, are described briefly as follows.

In one form, the present invention provides a composition comprising a combination of a fatty acid species or a salt thereof, and an organic acid species or a salt thereof, different from the fatty acid and its salts. In preferred embodiments, the composition also includes a wide variety of additives including one or more of emulsifiers, adjuvants, diluents, dispersants, and/or surfactants, to name just a few.

In another form, the present invention provides a fungicide composition comprising a fatty acid, or salt thereof, having between 5 and 22 carbon included in a fungicidally-effective amount and an organic carboxylic acid, or a salt thereof, that is different from the fatty acid. The fatty acid is an unsubstituted aliphatic carboxylic acid. The organic carboxylic acid has between 1 and 12 carbons and is substituted with one or more substituents selected from the group consisting of: hydroxyl, halide, oxygen, nitrogen, amine, sulfur, phosphate, carboxyl. The composition also can include a carrier and additives as listed above.

The fungicide can be formulated as a liquid concentrate that can be diluted with water to yield a ready-to-use formulation suitable for application to the locus of plants, their fruit, vegetable, seeds and/or nuts. The concentrate or the ready-to-use formulation can be supplied as an aqueous solution, a suspension, or an emulsion. The concentrate or the ready-to-use formulation can include additional components and be specifically formulated to target either a particular plant species crop and/or a particular pathogen.

In selected embodiments, the fatty acid species can be selected as a fatty monocarboxylic acid, having between 5 and 22 carbons. The fatty acid species can be saturated or unsaturated. The organic acid species can be selected from a wide variety of organic acids including monocarboxylic acids having between 1 and 12 carbon atoms which carbon atoms can be substituted with one or more of hydroxyl, halide, oxygen and nitrogen, or hydroxyl, halide, oxygen, nitrogen, amine, sulfur, phosphate, carboxyl substituents.

In still yet another form, the present invention provides a method of controlling fungus, said method comprising contacting one or more of plants, fruit, vegetables, seeds, and nuts with an effective amount of a ready-to-use composition prepared by diluting with water the concentrate listed above.

In still yet another form, the present invention provides a method of treating a crop product, said method comprising applying to the crop product a fungicidal composition comprising a fungicidally active amount of a fatty acid, having between 5 and 22 carbon atoms and an organic acid different from the fatty acid.

DETAILED DESCRIPTION OF THE INVENTION

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated herein and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Any alterations and further modifications in the described compositions, methods, or systems, and any further applications of the principles of the invention as described herein, are contemplated as would normally occur to one skilled in the art to which the invention relates.

In general, the present invention is directed to an agricultural composition particularly useful for treating plants under cultivation, agricultural products, produce, grains, cash crops, or other stable crops. The present composition finds particularly useful advantages as a fungicide. The agricultural composition can include one or more fatty acids in combination with one or more organic acids, that is/are different from the fatty acid(s). The composition can be provided either as a liquid concentrate or a ready-to-use formulation. Either the liquid concentrate or the ready-to-use formulation can be a clear, aqueous solution, a suspension, or an emulsion.

In particularly preferred embodiments, the agricultural composition includes additional components such as emulsifiers, diluents, adjuvants, dispersants, and/or surfactants. The agricultural composition can be applied to the locus of plants and/or to the agricultural products. For example, the agricultural composition can be applied either as a pre-emergent, post-emergent, foliar or post-harvest application. Additionally, the composition can be applied to agricultural products or crop products such as fruits, nuts, berries, vegetables, grains, seeds, stems, bark, leaves, or any other component derived from the plant either before or after harvesting the products. When applied to an agricultural product, the composition can be provided either as a spray or a dipped solution and can be used as a single or multiple treatment application. The agricultural composition can be used and applied prophylactically or to treat an emerging or existing fungicide infection.

The agricultural composition can include one or more fatty acids. The fatty acid can be selected from a wide variety of fatty acids commercially available

and/or widely known to those skilled in the art. In preferred embodiments, the fatty acid is selected to prevent, inhibit and/or retard fungal infections or fungal growth on plants. The fatty acids are aliphatic hydrocarbons with a terminal carboxylic acid functionality. Preferred examples of fatty acids include aliphatic, saturated, or unsaturated monocarboxylic fatty acids having between 5 and 22 carbon atoms. More preferably, the fatty acids are selected to have between 7 and 10 carbon atoms.

Preferably, fatty acids are selected that prevent, inhibit and/or retard fungal infections. Retardation or inhibition of fungal infections can be determined by a variety of commonly known evaluations. For example, the growth rate of fungi, measured in surface area of plant leaves or stems, can be measured and monitored over time. Consequently, it has been determined that certain fatty acids prevent, inhibit/retard fungal infections better than other fatty acids. Not to be limiting in any manner, it has been determined, for example, that fatty acids having 8 carbon atoms inhibit Botrytis cinerea on raspberries better than acids having 7 carbon atoms, which are better than acids having 9 carbon atoms, which are better than acids having 10 carbon atoms, all of which are better than acids having 6 carbon atoms.

Specific examples of available fatty acids for use in the present invention include pentanoic, hexanoic, heptanoic acid (enanthic acid), octanoic acid (caprylic acid), nonanoic acid (pelargonic acid), decanoic acid (n-capric acid), undecanoic acid, lauric acid, myristic acid, palmitic acid, stearic acid, oleic acid, linolenic acid, linoleic acid, erucic acid, palmitoleic acid, pentadecanoic acid, margaric acid, arachidic acid, arachidonic acid, behenic acid, and soya fatty acids, 2-hexyldecanoic acid, and the like.

The fatty acid is included in the agricultural composition in a desired amount; preferably in a fungicidally effective amount sufficient to elicit prevention or inhibition of fungal growth. In preferred embodiments, a concentrated formulation of the agricultural composition comprises between about 1 % v/v and about 99 % v/v of a fatty acid; more preferably, between about 50 and about 90 % v/v based upon the total volume of the concentrated formulation.

The agricultural composition also includes an organic acid that is different from the fatty acid. The organic acid can be selected from a wide variety of known and commonly used acids. The organic acid, in combination with one or more fatty acid(s) in the fungicidal composition, promotes additional or a synergistic fungicidal activity over that exhibited by the fatty acid(s) used individually or with one of the other additives. The organic acid can be selected to include acids having between 2 and 20 carbon atoms. The organic acids can be selected to be an aliphatic, saturated or unsaturated, cyclic, and/or aromatic. The acids can be mono acids, diacids, triacids, ketoacids, sugar acids, or hydroxy acids, each of which can be substituted with one or more oxygen, hydroxy groups, nitrogen, halide, or hydroxyl, halide, oxygen and nitrogen, or hydroxyl, halide, oxygen, nitrogen, amine, sulfur, phosphate, carboxyl substituents.

Specific examples of readily available organic acids for use in the present invention include but are not limited to mevalonic acid, glycolic acid, ketoglutaric acid, glutaric acid, glyceric acid, malonic acid, benzoic acid, trichloroacetic acid, pyruvic acid, cinnamic acid, formic acid, fumaric acid, isocitric acid, oxalacetic acid, acrylic acid, isobutyric acid, itaconic acid, humic acid, tetrahydrofurfuryl salicylic acid, diethylamine salicylic acid, fulvic acids, and sugar acids such as pentonic acid (i.e., ribonic acid and xylonic acid), hexonic acid (i.e., gluconic acid and galactonic acid), and bionic acids (i.e., saccharic acid and ascorbic acid), alanine, glycine, isoleucine, leucine, methionine, phenylalanine, proline, tryptophan, valine, asparagine, cysteine, glutamine, serine, threonine, tyrosine, aspartic acid, glutamic acid, arginine, histidine and lysineand mixtures of these acids.

A "ready-to-use formulation" of the agricultural composition (a concentrated formulation that is diluted in water or other diluent such as seed oil, ethanol, etc.) can include the organic acid species together with one or more fatty acid(s) in an amount sufficient to induce prevention, inhibition or retardation of fungal infection and comprises an amount of the fatty and organic acids less than the amount that will inhibit plant growth. In preferred embodiments, a ready-to-use formulation for use in the present invention comprises at least about 0.001 % v/v, of fatty and

organic acids; more preferably at least about 0.05 % v/v; and still yet more preferably at least about 0.01% % v/v of the fatty acid and organic acid, based upon the total volume of the formulation.

The agricultural composition can include both the fatty acids species and the organic acid species, different from the fatty acid species in a wide range of ratios. In preferred embodiments, the ratio of fatty acid species to organic acids species is in a weight ratio of between1:1000 to about 1000:1. More preferably, the weight ratio of fatty acid species to organic acid species is between about 1:5 to about 5:1. The agricultural composition for use in the present invention can be prepared by admixing all desired ingredients at the same time.

Alternatively, the fatty acid species can be premixed with one or more additives such as an adjuvants, surfactants, emulsifiers, and/or diluents in water. When premixed, the ratio of fatty acid to additive(s) can be between about 1:5 to about 1000:1. The fatty acid and additive(s), either singly or as a combined pre-mix, can be suitably dissolved in a solvent such as water, alcohol, and/or an organic solvent, such as an oil or ketone, suitable for treatment of agricultural products or plants.

In preferred embodiments, either the concentrate or the ready-to-use formulation is admixed with a variety of additives; for example, adjuvants, surfactants, emulsifiers, and/or diluents. The additive can be selected from a wide variety of known commercially available products. Typical adjuvants, surfactants, and/or emulsifiers for use with fatty acids include any synthetic or natural emulsifier including for example: organosilicones (i.e., Sylgard 309 sold by Dow Corning Corp, Kinetic, Silwet L77), methylated seed oil, and ethylated seed oil (i.e., Scoil sold by Agsco or Hasten sold by Wilfarm), alkylpolyoxyethylene ethers (i.e., Activator 90), alkylarylalolates (i.e., APSA 20), alkylphenol ethoxylate and alcohol alkoxylate surfactants (i.e., products sold by Huntsman), fatty acid and fatty amine ethoxylates (i.e., products sold by Huntsman), anionic surfactants such as sulfosuccinates, sulfonates, and phosphate esters (products sold by Huntsman), polyethylene glycol (PEG) fatty acid esters and alkyl napthalene sulfonates (i.e., products sold by Adjuvants Unlimited), tristyrylphenol, castor, oil and fatty amine

ethoxylates and products sold by Cognis such as sorbitan and ethoxylated sorbitan esters, ethoxylated alcohols and alkylphenols, ethoxylated vegetable oils, alkyl, glycol and glycerol esters. Also to be included are natural emulsifiers such as lecithin. Examples of diluents include mineral oil and natural oils such as vegetable oil, coconut oil, olive oil, corn oil, canola oil, cottonseed oil, and soybean oil, to name just a few.

In selected embodiments, a "ready-to-use formulation" (i.e., a concentrated formulation diluted in water or other solvent) according to the present invention contains between about 0.001 % v/v and about 3 % v/v fatty acid, more preferably between about 0.005 % v/v and about 2.0 % v/v of the fatty acid, still more preferably between about 0.01 % v/v and about 1.0 % v/v of the fatty acid. The organic acid is included in an amount between about 0.001 % v/v and about 4% v/v; more preferably, between about 0.1 % v/v and about 1 % v/v (or wt/vol, for solid organic acids). When used as a foliar spray application treatment, the fungicide composition can be directly applied to the crop products; i.e., leaves, fruit or other crops, such as fruit, vegetables, berries, nuts, seeds, and the like. Furthermore, in use, the fungicide composition can be applied as a single use or single treatment, or in multiple treatments.

In other embodiments, the fungicide composition can be combined with one or more other treatment processes and compositions. For example, the fungicide composition can be combined with a herbicide composition, a desiccant composition, or an insecticide composition. A combination of the fungicide with one or more other treatment compositions and applications obviously reduces treatment costs and consequently can improve efficiency of operation.

In preferred embodiments, the selected combination of a fatty acid species and an organic acid species exhibits unexpected results or synergism by providing improved fungicidal activity over any of the individual components by themselves. The organic acid, alone, has little or no fungicidal activity; however, when combined with the fatty acid, a strong synergism results.

The crop products can be selected from any commonly known or used cash crops including fruits, vegetables, berries, nuts, leaves, seeds, grains and the like.

Specific examples in which the fungicide composition finds particular use include crops, strawberries, raspberries, blueberries, melons, stone fruit, nut crops, potatoes, vegetables, turf grasses, seed crops (i.e., seed grasses, alfalfa seed), corn, rice, wheat, soybeans, dry beans, peanuts, cotton, sorghum, and other row crops, curcurbits, other small fruit crops, and horticultural plants.

The fungicide composition can be provided to the end user either as a liquid concentrate or in a "ready-to-use composition" (i.e., a concentrated formulation diluted in water or other diluent). When provided as a liquid concentrate, the fungicide composition includes the fatty acid species in a range, of between about 1 % v/v and about 99 % v/v, the organic acid species in a range between about 0.1% v/v and about 90 % v/v, and the additives in a range between about 0.01 % v/v and about 80 % v/v.

In another embodiment, the fungicide composition can be provided as: (a) a harvest aid to desiccate foliage, stems, and/or vines prior to harvest crops such as seed grasses, onions, potatoes, cotton, and dry beans, or (b) a preservative to treat and/or preserve the harvested crops such as fruits, vegetables, berries, nuts, leaves, seeds, grains, and the like. When provided as a preservative, the fungicide composition can be applied either as a spray or as a dip solution. When provided as a dip solution, the fungicide composition can be used in a large vat in which the harvested crop is dipped into the liquid composition. Thereafter, the submerged crop is removed from the fungicide composition and allowed to drain followed by drying. The dried product can then be safely stored for use at a later time. Furthermore, when used as a preservative, the fungicide composition can be used immediately after harvest or at any time subsequent to harvesting.

The fungicide composition exhibits a broad range of fungicide activity against a large number of target pathogens. Non-limiting examples of specific pathogens targeted by the fungicide composition include: Botrytis cinerea (i.e., Botrytis bunch rot, gray mold, Botrytis blight), Phomopsis viticola (i.e., Phomopsis cane and leaf spot), Phomopsis rachis, Phomopsis vaccinii (i.e., Phomopsis twigblight and canker), downy mildew, Sphaerotheca macularis (i.e., powdery mildew), Guignardia bidwellii (i.e., black rot), Monilinia vacinii-corymbosi (i.e., mummy

berry), Phragmidium sp. (i.e., yellow rust), Drepanopeziza sp. (i.e., anthracnose), Kuehneola sp. (i.e., cane and leaf rust), Sphaerulina sp. (i.e., orange rust), Arthuriomyces sp. (i.e., powder mildew), Mycosphaerella sp.(leaf spot), Colletotrichum acutatum (i.e., anthracnose fruit rot), Verticillium albo-atrum (i.e., Verticillium wilt), Phytophthora fragariae (i.e., red stele root rot), Dendrophoma obscurans (i.e., stem end rot, leaf blight), Phytophthora cactorum (i.e., leather rot), Diplocarpon earliana (i.e., leaf scorch), Godronia cassandrae (i.e., fusicoccum canker), Alternaria sp. (i.e., Alternaria fruit rot), Exobasidium vaccinii (i.e., red leaf disease), Microsphaera vaccinii (i.e., powdery mildew), Venturia inaequalis (i.e., apple scab), Gymnosporangium sp. (i.e., apple rust), Podosphaera leucotricha (i.e., apple powdery mildew), black rot of apple, blossom end rot of apple, blue mold of apple, brown rot of stone fruit, Rhizopus sp., Leucostoma cincta or Leucostoma persoonii (i.e., cytospora canker of stone fruits), white rot of apple, Monilinia fructicola (i.e., brown rot of stone fruit), Blumeriella jaapii (i.e., cherry leaf spot of stone fruit), sooty mold of pear, pear leafspot, pear leaf blight and fruit spot, Pythium ultimatum, Phytophthora infestans (late blight, potatoes), Aspergillus sp. (i.e., Aspergillus paraciticus), Apiosporina morbosa (i.e., black knot of stone fruit), Rhizoctonia solani (i.e., black scurf in potatoes, aerial blight, soybeans), Alternaria solani (early blight, potatoes), Sclerotium rolfsii (i.e., Sclerotium rot, sugar beets), Fusarium sp., Septoria sp. and white mold in soybeans and the like.

For the purpose of promoting further understanding and appreciation of the present invention and its advantages, the following examples are provided. It will be understood, however, that these examples are illustrative and not limiting in any fashion. Unless specifically indicated to the contrary, all percentages listed below in the following examples are percentage by volume, based upon the total volume of the resulting composition.

EXAMPLE 1: Retardation of White Mold Growth on Soybean Foliage

Soybean foliage was treated with caprylic acid with a solution that contains sorbitan monolaurate, sold under the trade name Emsorb 6915 by Cognis, and

mineral oil. A stock solution of the caprylic acid was formulated to include about 0.75% caprylic acid, about 1% HASTEN (or 0.5% Sylgard 309), about 0.21% sorbitan monolaurate, and about 0.11% mineral oil by volume percent. This was applied to plants at 40 gallons per acre (gpa). The plants were about 9-12 inches in height. Foliage from the plants was collected at days 2, 4, 7, and 34 after fungicide treatment, washed in warm water, drained, and then inoculated with the mold inoculum. White mold inoculum (5 mm diameter plugs) was used to infect the foliage of soybean plants (species GL2415). The inoculated foliage was incubated for 2-3 days at room temperature (at 100% humidity) under fluorescent lighting. The results are listed below in Table 1.

TABLE 1

Treatment Solution	Average radii of fungal growth[1] at days after fungicide treatment:			
	2	4	7	34
Control (untreated)	100	100	100	100
0.21% 6915 + 0.11% mineral oil + 0.75% caprylic acid + 1% HASTEN	50	44	52	*
0.29% 6915 + 0.14% mineral oil + 1% caprylic acid + 1% HASTEN	55	45	35	*
0.21% 6915 + 0.11% mineral oil + 0.75% caprylic acid + 0.5% SYLGARD	46	47	26	66
0.29% 6915 + 0.14% mineral oil + 1% caprylic acid + 0.5% SYLGARD	53	29	38	67

[1] Fungal growth for Control (treatment 1) is expressed as 100 %.

From the results listed above, it can be determined that even as little as 0.75% caprylic acid demonstrated significant reduction in the fungal growth on soybean foliage.

EXAMPLE 2: Retardation of White Mold Growth on Soybean Foliage

The foliar treatments were applied at a rate of 40 gpa (40 psi) to 4 soybean plants (15-20" in height) per each treatment group (Table 2). Two leafs/plant were

used for the detached leaf assay. White mold inoculums (5 mm plugs from potato dextrose agar plates) were used to inoculate soybean foliage (species GL 2415). Foliage from the soybean plants were washed in warm water, drained, collected and inoculated, and the inoculated foliage was incubated for 3 days at room temperature (100% humidity) under fluorescent lighting. The results are listed in Table 2 below.

TABLE 2

Treatment Solution	Average Radii (mm)[2]	Percent Fungal Growth Based on Control
Control (untreated)	3.14	100%
0.21% 6915[1] + 0.11% mineral oil	3.012	96
0.2% 6915[1] + 0.11% mineral oil + 0.75% caprylic acid	2.225	71
0.07% 6915[1] + 0.04% mineral oil + 0.25% caprylic acid	2.75	88
0.02% 6915[1] + 0.01% mineral oil + 0.08% caprylic acid	2.813	90

[1] Cognis Emsorb 6915

[2] Average radii (mm) of fungal growth on leaf surface measured at day 3

From the results listed in Table 2 it can be demonstrated that caprylic acid significantly inhibits the fungal growth of white mold on soybean foliage. The orthogonal comparison of the control 1 and treatment solution 3 was statistically significant at $P > 0.95$, and orthogonal comparison of treatment solution 2 versus treatment solution 3 indicated that treatment 3 was statistically significant at $P > 0.90$.

EXAMPLE 3: Reduction of Phytophthora Infestans on Potato Foliage at 1 and 10 Days After Treatment

Snowden potatoes were grown in Baccto potting soil to a height of 14-21 inches. All plants were fertilized one time per week. The plants were then treated as listed below in Table 3. The treatment solutions listed below in Table 3 were applied at 40 gpa (40 psi) to three plants (3 plants per treatment group). Each treatment included 0.2% SYLGARD 309 sold by Dow Corning. At one and ten days after treatment, foliage (4 leafs per plant) were washed in warm water,

drained and inoculated. The inoculated foliage was incubated for 2-3 days at room temperature (100% humidity) via fluorescent lighting. P. infestans plugs from PDA plates were used to inoculate 4 leaves/plant. The results are listed below in Table 3.

TABLE 3

Treatment Solution	Average radii (mm) of Growth (*P. infestans*)	
	Day 1	Day 10
1. 0.57% 6915[1] + 0.29% mineral oil	9.49 100%	8.35 100%
0.57% 6915[1] + 0.29% mineral oil + 2% caprylic acid	1.24 13%[2]	1.35 16%[3]

[1] Cognis Emsorb 6915
[2] Based upon the control at Day 1 after application of treatments
[3] Based upon the control at Day 10 after application of treatments

From the results listed above in Table 3, it can be determined that a solution containing 2% caprylic acid significantly inhibits the growth of Phytophthora infestans on potato foliage. The treatment solution 2 was significantly different from the treatment 1 for disease control as determined via an ANOVA statistical test ($P > 0.95$).

EXAMPLE 4: Inhibition of Fungus Infection on Strawberries

A field of strawberries (Northeaster variety) was partitioned into four separate areas. Strawberries were harvested from the four separated areas. For each treatment group, berries were randomly selected from the four separate areas. Berries were submersed for 60 seconds in the specified treatment solution listed below in Table 4. After 60 seconds, the berries were removed from the solution, briefly drained, and incubated at room temperature on a screen suspended above water in a sealed chamber. The infected berries were analyzed to determine the host fungi. The primary host fungi were Botrytis cinerea, and the secondary fungi were Rhizopus. The results are listed below in Table 4.

TABLE 4

Group	Treatment Solution	Infected berries (% of total) determined at The specified days after treatment (DAT)				
		Day 3	Day 4	Day 5	Day 6	Day 7
1.	Water	70%	85%	100%	100%	100%
2.	0.35% glycolic acid	75%	90%	100%	100%	100%
3.	0.35% glycolic acid and 0.35% caprylic /0.1% 6915[1]/0.05% mineral oil	5%	15%	20%	30%	40%
4.	0.35% caprylic acid/0.1% 6915[2]/0.05% mineral oil	25%	50%	60%	65%	75%

[1] Cognis Emsorb 6915

It can be determined from analyzing the results listed above in Table 4 that caprylic acid (treatment #4) exhibits a significant inhibition of fungus infection. However, it is also determined that the combination of glycolic acid and caprylic acid (treatment #3) provide unexpected and synergistic inhibition of fungal infection of strawberries. No inhibition is found when only glycolic acid is used.

EXAMPLE 5: Inhibition of Fungus Infection on Strawberries

Strawberries described and treated as above in Example **4**, with the solutions shown below in Table 5.

TABLE 5

Group	Treatment Solutions	Infected berries (% of total) on days after treatment		
		Day 2	Day 3	Day 4
1.	Water	75%	90%	100%
2.	0.35% glycolic acid	70%	95%	100%
3.	0.35% glycolic acid + 0.70% caprylic acid/0.20% 6915[2]/0.10% mineral oil	0%	0%	5%
4	0.70% caprylic acid /0.20% 6915[1]/0.10% mineral oil	25%	60%	95%

[1] Cognis Emsorb 6915

The data demonstrate the synergist fungicidal activity of caprylic and glycolic acids.

EXAMPLE 6: Inhibition of Fungal Infections on Strawberries: Comparison of Various Organic Acids as Synergists with Caprylic Acid

Strawberries (Northeastern) were selected and treated as described above in Example 5 with the solutions listed below in Table 6. The predominant fungal infection was Botrytis cinerea and the secondary infection was Rhizopus.

TABLE 6

Group	Treatment Solution	Infected berries (% of total treated berries): days after treatments #1-7				
		Day 2	Day 3	Day 5	Day 7	Day 9
1.	Water	60%	75%	95%	95%	95%
2.	0.7% caprylic acid /0.2% 6915[1]/0.1% mineral oil	5%	25%	55%	75%	80%
3.	0.7% caprylic acid /0.2% 6915[1]/0.1% mineral oil and 0.35% glycolic acid	0%	0%	0%	0%	5%
4.	0.7% caprylic acid/0.2% 6915[1]/0.1% mineral oil and 0.35% potassium sorbate	0%	0%	15%	25%	30%

[1] Cognis Emsorb 6915

For Northeastern strawberries, glycolic acid in combination with caprylic acid exhibited unexpectedly high anti-fungal properties and was the best treatment under the test conditions.

EXAMPLE 7: Inhibition of Fungus Infections on Raspberries

Raspberries (Tulamen variety) harvested from four separate plots were divided into three groups, each group of harvested berries were submerged for 60 seconds in the appropriate solution listed below in Table 7, briefly drained and dried and then incubated at room temperature on a screen suspended above water in a sealed chamber. The predominant infection observed on the raspberries was Botrytis cinerea and the secondary infection was Cladosporium. The results are listed below in Table 7.

TABLE 7

Group	Treatment Solution	Infected berries (% of total) on days after treatment			
		Day 2	Day 3	Day 4	Day 5
1.	Water	61%	85%	96%	96%
2.	0.7% caprylic acid/0.2% 6915[1]/0.1% mineral oil + 0.5% glycolic acid	0%	0%	0%	0%
3.	0.7% caprylic acid/0.12% oleic acid/0.01% Leciprime	0%	0%	0%	0%

[1] Cognis Emsorb 6915

EXAMPLE 8: Inhibition of Fungal Growth by Caprylic Acid and Glycolic Acid.

Potato dextrose agar (PDA) plates, +/- amendments (treatments #1-6, Table 8), were inoculated with Septoria, late blight or white mold. There were four replicate plates/treatment group/fungus type. After incubation of the plates at room temperature (three days), fungal growth was measured.

TABLE 8

Group	Amendments in PDA Plates	Measurement of fungal growth on day 2 or 3 after inoculum[4]					
		Septoria		Late blight		White mold	
		Day 2	Day 3	Day 2	Day 3	Day 2	Day 3
1.	0.0175% C-8[1]/0.005% 6915/ 0.003% mineral oil	92	94	82	93	24	52
2.	0.0175% C-8[1]/0.005% 6915/ 0.003% mineral oil and 0.0175% glycolic acid	60	69	65	78	41	65
3.	0.07% C-8[1]/0.02% 6915[2]/0.01% mineral oil	0	19	10	25	0	0
4.	0.07% C-8[1]/0.02% 6915[2]/0.01% mineral oil and 0.0175% glycolic acid[3]	0	2	0	10	0	0
5.	0.0175% glycolic acid[3]	80	90	79	104	127	108
6.	no amendments	100	100	100	100	100	100

[1] C-8 stock solution: = 70% caprylic acid /20% 6915/10% mineral oil
[2] Cognis Emsorb 6915 (sorbitan monolaurate)
[3] Glycolic acid = DuPont 70% glycolic acid
[4] Based on fungal growth on the control plate (100%)

Addition of glycolic acid enhanced fungicidal activity of caprylic acid (C8).

EXAMPLE 9: Inhibitions of Fungal Infections on Fresh Raspberries

Raspberries (Heritage variety) were harvested from four plots. Nine berries per plot (4 plots) were used for each treatment group. The berries were randomly divided into seven (7) groups. Each group of the harvested berries were submersed for 60 seconds in the appropriate solution listed below in Table 9. Thereafter the berries were removed from the solution, briefly drained and incubated at room temperature on a screen suspended above water in a sealed chamber. The predominant infection for the berries was determined to be Botrytis cinerea. The results are listed below in Table 9.

TABLE 9

Group	Treatment Solution	Infected berries (% of total) on days after treatment						
		Day 2	Day 3	Day 4	Day 6	Day 8	Day 10	Day 12
1.	Water	33%	83%	89%	89%	89%	92%	92%
2.	0.525% caprylic acid/ 0.15% 6915[1]/0.075% mineral oil	0	0	11%	17%	44%	67%	67%
3.	0.75% tartaric acid	31%	58%	86%	92%	92%	92%	92%
4.	0.525% caprylic acid/0.087% oleic acid/0.009% Leciprime[2]	0	0	0	3%	3%	3%	8%
5.	0.263% caprylic acid/0.044% oleic acid/0.005% Leciprime[2]	0	0	0	6%	14%	25%	33%
6.	0.131% caprylic acid/0.022% oleic acid/0.002% Leciprime[2]	3%	8%	11%	14%	25%	28%	28%

[1] Cognis Emsorb 6915 (sorbitan monolaurate)
[2] Leciprime is a lecithin product

EXAMPLE 10: Inhibitions of Fungal Infections on Fresh Raspberries: Comparison of Various Fatty Acid Species (C6-C10) as Fungicide Active Ingredients

Raspberries (Heritage variety) were harvested and treated as described above in Example 9. The results of the treatments for various saturated fatty acids are listed below in Table 10.

TABLE 10

Group	Treatment Solutions	Infected berries (% of total) on days after treatment						
		Day 1	Day 2	Day 3	Day 5	Day 7	Day 9	Day 11
1.	Water	19%	58%	92%	97%	97%	97%	97%
2.	0.1% 6915[1]/0.05% mineral oil/ 0.35% caproic acid	3%	39%	75%	97%	97%	97%	100 %
3.	0.1% 6915/0.05% mineral oil/ 0.35% heptanoic acid	0%	0%	6%	44%	69%	83%	89%
4.	0.1% 6915/0.05% mineral oil/ 0.35% caprylic acid	0%	0%	3%	25%	53%	67%	78%
5.	0.1% 6915/0.05% mineral oil/ 0.35% pelargonic acid	0%	3%	14%	68%	89%	92%	97%
6.	0.1% 6915/0.05% mineral oil/ 0.35% capric acid	0%	31%	69%	97%	100 %	100 %	100 %

[1] Cognis Emsorb 6915 (sorbitan monolaurate)

The above data indicate that the relative fungicidal activity of the fatty acid species against raspberry pathogens was: caprylic > heptanoic > pelargonic > capric > caproic acid.

EXAMPLE 11: Effects of Fungicide Formulation on Greenhouse Soybean Production

Five (5) groups of soybean plants (variety GL 2415) were grown to a height of 15-20 inches and then each group was treated with the indicated solutions listed below in Table 11. Each plant was treated with a solution at an application rate of 40 gpa at (40 psi). After treatment, the soybean plants were grown in a greenhouse for 31 days prior to harvest. The results of harvesting are listed below in Table 11.

TABLE 11

Group	Treatment Solutions	Average production/plant[2]		
		Bean number	Total bean Weight (grams)	Weight (g) Per bean
1.	Control (untreated)	16.3	18.3	1.10
2.	0.21% 6915[1] + 0.11% mineral oil	22.8	25.7	1.13
3.	0.21% 6915[1] + 0.11% mineral oil + 0.75% caprylic acid	20.8	22.5	1.10
4.	0.07% 6915[1] + 0.04% mineral oil + 0.25% caprylic acid	21.0	24.2	1.14
5.	0.02% 6915[1] + 0.01% mineral oil + 0.08% caprylic acid	21.3	23.7	1.11

[1] Cognis Emsorb 6915

[2] Four repetitions (plants) per treatment group.

It can be seen from the data listed in Table 11 above that none of the caprylic acid (C8) treatments adversely affected soybean production. Moreover, there was no phytotoxicity (visual injury) from any of the caprylic acid treatments.

EXAMPLE 12: Efficacy of Selected Formulations Containing amendment Tetrahydrofurfuryl salicylate and Huntsman PE 1198 Emulsifier as inhibitors of selected fungal pathogens

Potato dextrose agar (PDA) plates, +/- amendments, were inoculated with selected pathogens. There were several replicate plates used per treatment group (per pathogen tested). After incubation of plates at room temperature, fungal growth was measured.

TABLE 12

Treatment Solutions	% inhibition of selected pathogens[1]									
	0.015%, v/v of formulations					0.100%, v/v of formulations				
	Late Blight	Alt	Botry	Pyth U.	White Mold	Pestal	Collet	C. paras.	A. Paras.	A. Porric.
1 = 85% pelargonic acid 15% Huntsman PE1198	15	49	30	27	76	85	52	44	66	74
2 = 85% pelargonic acid 7% Huntsman PE 1198 8% tetrahydrofurfuryl salicylate	27	42	21	33	53	79	41	45	48	79
3 = 70% caprylic acid 10% Huntsman PE 1198 20% tetrahydrofurfuryl salicylate	31	44	42	26	58	88	48	50	50	80
4 = 70% pelargonic acid 10% Huntsman PE 1198 20% tetrahydrofurfuryl salicylate	23	41	21	32	52	86	47	59	39	77
5 = 55% pelargonic acid 10% Huntsman PE 1198 35% tetrahydrofurfuryl salicylate	49	44	20	42	39	84	46	68	74	80
6 = 40% pelargonic acid 10% Huntsman PE 1198 50% tetrahydrofurfuryl salicylate	77	45	19	44	29	79	53	66	72	82

[1]Late blight = Phytophthora
Alt= Alternaria (SWREC)
Botry = Botrytis cinerea (SWREC)
Pyth. U. = Pythium ultimum
Pestal = Pestalotia infestans
Collet = Colletotrichia (SWREC)
C. para = Cylindrocladium parasiticus
A.paras. = Aspergillus parasiticus

The average percent inhibition of all pathogens
1= 47.7%
2= 54.6%
3= 56.6%
4= 51.7%
5= 46.8%
6= 51.8%

The combination of tetrahydrofurfuryl salicylate and pelargonic acid exceeded the fungicidal activity of pelargonic acid, alone.

EXAMPLE 13: Synergism Between Caprylic Acid and Organic Acids: Inhibition of Botrytis cinerea and White Mold

Potato dextrose agar (PDA) plates, +/- amendments, were inoculated with selected pathogens. There were several replicate plates used per treatment group (per pathogen tested). After incubation of plates at room temperature, fungal growth was measured.

TABLE 13

	Treatment*	Inhibition (%) of Botrytis cinerea	Inhibition (%) of white mold
1	0.014% caprylic acid	88	34
2	0.014% caprylic acid + 0.010% glycolic acid	98	71
3	0.014% caprylic acid + 0.010% diethylamine salicylate	99	93
4	0.010% citric acid	0	0
5	0.010% succinic acid	0	0
6	0.010% glycolic acid	0	0
7	0.010% diethylamine salicylate	0	7

Synergy between caprylic acid and each organic acid for white mold
Synergy between caprylic acid and each organic acid for Botrytis
*Treatment formulation: 70% C-8/ 20% Emsorb 6915/ 10% mineral oil: 0.020%, v/v, of formulation = 0.0140% C-8 in potato dextrose agar plate
Stoichiometric amounts of organic acids used in treatment

Combinations of caprylic acid (C8) with organic acids for both pathogens were synergistic.

EXAMPLE 14: Comparison of Low and High Rates of Caprylic Acid Applied to Strawberry and Potato Plant Foliage: Inhibition of Botrytis cinerea

The foliage of strawberry plants, (Honeoye variety) and potato plants (Snowden variety) were inoculated with fresh B. cinerea and incubated at room temperature in moisture chambers for 2-3 days. The inoculated foliage of the plants were then treated with the treatment solutions listed in Table 14 below. It should be noted that no phytotoxicity was observed in any of the treatment solutions.

TABLE 14

	Treatment Solutions	Inhibition (%) of Botrytis on Potato Foliage	Inhibition (%) of Botrytis on Strawberry Foliage
1	Water	0	0
2	0.08% caprylic acid formulation	15	62
3	0.08 caprylic acid formulation + 0.02% glycolic acid	46	53
4	1.5% caprylic acid formulation	20	61
5	1.5% caprylic acid formulation + 0.02% glycolic acid	46	52

Actual caprylic acid concentration in treatment #2, 3 was 0.056%
Actual caprylic acid concentration in treatment #4, 5 was 1.050%
Application of treatments at 20 gallons/acre (25 psi)
Foliage inoculated with fresh B. cinerea and incubated at room temperature in moisture chambers for 2-3 days
Strawberry and potato varieties were Honeoye and Snowden, respectively.
Caprylic acid formulation: 70% caprylic acid/20% Cognis Emsorb 6900/10% mineral oil
Glycolic acid (70%) from DuPont
No phytotoxicity observed

The data indicate that a lower application rate of formulation containing caprylic acid (C8, 0.08%) exhibited a similar fungicidal activity as a higher application rate of the caprylic acid (C8 at 1.5%). Further, formulations containing glycolic acid exhibited enhanced fungicidal activity on potato foliage than similar formulation without the addition of the glycolic acid.

EXAMPLE 15 Inhibition of White Mold on Vista Dry Bean Foliage: Caprylic Acid Formulations Containing Different Adjuvants

Experimental details given below in Table 15 illustrate that the addition of tetrahydrofurfuryl salicylate enhanced the fungicidal activity of formulations containing caprylic acid (C8) against white mold.

TABLE 15

Treatment Solutions	Percent Inhibition of White Mold
Water, control	0
70% caprylic acid/20% Cognis 6915/10% mineral oil	61
51% caprylic acid/39% Cognis 6915/10% high fructose corn syrup	60
47% caprylic acid/36% Cognis 6915/17% tetrahydrofurfuryl salicylate	92
55% caprylic acid/41% Cognis 6915/4% Exacto 390	50

Same amount (0.42%) of caprylic acid used in all treatments

All formulations, as concentrated emulsions or diluted in water, were stable; i.e., no phase separation was observed after storage of emulsions for several days. Twelve leaves/treatment group, after treatment, inoculated with white mold from PDA plates. Leaves incubated at 100% humidity for 2 days and zones of infection measured.

No phytoxicity observed for any of the treatments.

EXAMPLE 16: Inhibition of Rhizoctonia solani on cotton foliage

The combination of caprylic acid (C8) and tetrahydrofurfuryl salicylate with an emulsifier, PE 1198, was highly effective against R. solani.

TABLE 16

Treatment Solution	Application Rate*	Percent Inhibition of R. solani
Water, control		0
70% caprylic acid/20% PE 1198/10% tetrahydrofurfuryl salicylate	0.1%, v/v	89
70% caprylic acid/20% PE 19198/10% tetrahydrofurfuryl salicylate	0.2%, v/v	94

*0.1 or 0.2%, v/v, formulation, in water

Foliage dipped in treatment, drained, dried, and inoculated with fresh culture of Rhizoctonia solani from PDA plate.

Four leaves from each plant/treatment group inoculated and incubated at 100% humidity for 7 days.

PE 1198 emulsifier from Huntsman

EXAMPLE 17: Comparison of Caprylic Acid and Pelargonic acid as Active Ingredients in Fungicides and Comparison of Emulsifiers

Potato dextrose agar (PDA) plates, +/- amendments, were inoculated with selected pathogens. There were several replicate plates used per treatment group (per pathogen tested). After incubation of plates at room temperature, fungal growth was measured.

TABLE 17

		% Inhibition of Selected Pathogens by Formulations							
	Treatment Solutions*	C. para.	Alt	Late Blight	S. Minor	Pyth. U.	Botr	White Mold	Avg
1	85% caprylic acid/15% PE 1198	7	33	14	83	12	30	68	35
2	85% pelargonic acid/15% PE 1198	7	31	25	84	20	25	80	39
3	85% caprylic acid/15% 6915	1	11	0	66	7	17	65	24
4	85% pelargonic acid/15% 6915	1	12	0	78	17	13	76	28
5	85% caprylic acid/15% 6900	0	10	0	75	5	20	53	23
6	85% caprylic acid/15% 6964	0	22	8	85	9	40	65	33

*0.015%, v/v, formulation used (actual C8 or C9 used was 0.013%)
C. para = Cylindrocladium parasiticus
Alt = Alternaria
Late blight = Phytophtora infestans
S. minor = Schlerotinia minor
Pyth. U. = Pythium ultimum
Botr = Botrytis cinerea
White mold = Sclerotinia sclerotiorum

The data listed in Table 17 above indicate that pelargonic acid exhibited slightly better or same fungicidal activity as caprylic acid against a wide variety of fungi (PDA plate assay). Further the emulsifier, PE 1198, provided better results than other comparable emulsifiers.

EXAMPLE 18: Comparison of Caprylic Acid (C8) and Pelargonic acid (C9) +/- stoichiometric amounts of organic acid amendments.

Potato dextrose agar (PDA) plates, +/- amendments, were inoculated with selected pathogens as listed below in Table 18. There were several replicate plates used per treatment group (per pathogen tested). After incubation of plates at room temperature, fungal growth was measured.

TABLE 18

Treatment Solution*	% Inhibition by C8 (C9) +/- Organic Acid									
	Late Blight		Alternaria		Botrytis		Pyth U.		White Mold	
	C8	C9	C8	C9	C8	C9	C8	C9	C8	C9
C8 or C9	85	61	48	41	57	39	57	48	96	93
+ glycolic acid 100%	98	96	62	56	78	78	100	74	96	97
+ glycolic acid, 70% (tech)	99	91	62	59	86	76	100	74	96	97
+ gluconic acid	91	90	45	53	90	43	94	61	87	83

*The treatment solution was added to PDA

C8, caprylic acid, and C9, pelargonic acid, at 0.025% in PDA (potato dextrose agar) plates

Organic acids at 0.013% in PDA (acids at same dry wt. basis)

Both C8 and C9: 85% C8 or C9/15% 6915 (concentrated emulsions used in PDA)

The data above indicate that overall, caprylic acid (C8) (+/- organic acids) exhibited greater fungicidal activity than pelargonic acid (C9) (+/- organic acids).

As can be seen from the above, the present invention provides novel compositions useful for treating plants, and their fruits, vegetables, seeds and/or nuts to prevent or inhibit fungus growth and formation. The composition can be used either prophylatically to inhibit and prevent fungus growth and/or to treat existing fungus. It has been determined that the combination of a fatty acid and an organic acid different from the fatty acid provides unexpectedly high fungicidal activity. Further, it has also been determined that fungicidally effective agricultural formulations can be prepared containing as little as 0.01 % v/v of the fatty acid. The formulations are effective against a wide spectrum of fungal

species. Further the formulations exhibit little or no phytotoxicity toward crop producing plants when applied at fungicidally effective amounts.

The present invention contemplates modifications to the fungicide formulations as would occur to those skilled in the art without departing from the spirit of the present invention including combining the fungicide formulations with other agriculturally acceptable components either active or inactive. In addition, the fungicide formulations can be applied by various application methods, and at differing rates and on different plants as would occur to those skilled in the art.